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EXAMINER

KIELIN, E

ART UNIT PAPER NUMBER

2813

12

DATE MAILED:

06/28/01

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trad marks

Office Action Summary

Application No.

09/388,826

Applicant(s)

Li et al.

Examiner

Erik Kielin

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on May 25, 2001
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1, 2, 4-12, 14, 16, 18, 20-25, 34-37, 39-42, 44-46, 48-51, and 61 is/are pending in the application.
- 4a) Of the above, claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1, 2, 4-12, 14, 16, 18, 20-25, 34-37, 39-42, 44-46, 48-51, and 65 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are objected to by the Examiner.
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

- 13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).
- a) ☐ All b) ☐ Some* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- *See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

- 15) ☒ Notice of References Cited (PTO-892) 18) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 16) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 19) ☐ Notice of Informal Patent Application (PTO-152)
- 17) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s). 10 20) ☐ Other: _____

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DETAILED ACTION

Request for Continued Examination

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 5/25/01 has been entered.

Election/Restriction

2. Claims 13 and 38 withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected species, there being no allowable generic or linking claim. Election was made **without** traverse in Paper No. 11.

Claim Rejections - 35 USC § 112

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. Claims 16 and 18 are rejected under 35 U.S.C. 112, first paragraph, because the specification, while being enabling for *a portion* of the $(\text{CH}_3)_x\text{SiO}_y$ to remain as $(\text{CH}_3)_x\text{SiO}_y$ upon

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exposure to the oxygen plasma, does not reasonably provide enablement for all to remain as $(\text{CH}_3)_x\text{SiO}_y$. The specification does not enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to use the invention commensurate in scope with these claims.

It is held, absent evidence to the contrary that, it is not possible for all to remain as $(\text{CH}_3)_x\text{SiO}_y$. The prior art to be presented below clearly indicates that the oxygen plasma necessarily reacts with the methyl function, thereby breaking the bonds. See **Wang et al.** (US 6,028,015), **Morita** (JP 63-157443 A), or **Brinker et al.** (US 5,948,482) for verification. Each of which, as indicated below, teaches that oxygen plasma necessarily removes a portion of the organic moiety from the dielectric layer.

Applicant argues that, “the specification is enabling for all of the layer to **substantially** remain chemically the same.” (Emphasis added.) **This is not claimed.** The claim specifically requires **all** to remain the same not “substantially” the same.

Applicant further argues that Examiner’s assessment of the cited art is incorrect. Examiner respectfully disagrees, and further asserts that Applicant’s assessment of each of the cited references is grossly incorrect in asserting that none of the references teach that the oxygen plasma breaks the Si-C bond of the Si-CH_3 moiety. First, Examiner agrees with Applicant in that **Wang** removes the photoresist using oxygen plasma ashing of the photoresist. **Wang** however, specifically states that such oxygen plasma severs the Si-C bond of the Si-CH_3 moiety, as below,

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and as *clearly underlined* by Examiner in the copy sent to Applicant, and apparently disregarded by Applicant. It is repeated here for further clarification:

"In particular, for example, when the surface of such a low dielectric constant **methyl silicon oxide** insulation layer is exposed to **oxidizing or "ashing" systems, which are used to remove a photoresist mask from the low dielectric constant methyl silicon oxide** insulation layer, after formation of openings therein, it has been found that the **ashing** process results in damage to the bonds (**severance**) **between the methyl radicals and the silicon atoms** adjacent the surfaces of the low dielectric constant methyl silicon oxide insulation layer exposed to such an ashing treatment. The term "openings", as used herein, is intended to describe either vias between two layers of metal interconnects or contact openings between devices on the substrate and a metal interconnect layer. **This severance of the carbon-silicon bonds, in turn, results in removal of such organic materials formerly bonded to the silicon atoms** along with the organic photoresist materials being removed from the integrated circuit structure. The **silicon atoms from which the methyl radicals have been severed**, and which are left in the damaged surface of the low dielectric constant methyl silicon oxide insulation layer, have dangling bonds which are very reactive and become water absorption sites if and when the damaged surface is exposed to moisture." (Emphasis added; column 1, line 52 to column 2, line 7.)

Wang indicates further in this regard,

"...i.e., those silicon atoms **previously** bonded to organic radicals stripped from the silicon atoms by exposure to the **oxidizing/ashing treatment** used to remove resist mask 40. (Emphasis added; column 3, lines 50-52.)

Wang further indicates that the "oxidizing/ashing" means of removing the photoresist is **O₂ (oxygen) plasma**, as below:

"The respective resist masks wo[u]ld then be removed from both wafers by a **standard ashing process** consisting of an **O₂ plasma**." (Emphasis added; column 5, lines 3-5.)

Similarly, the translation of **Morita** states,

"When this semiconductor substrate 1 is exposed to an **oxygen plasma** for ten minutes, the **organic functional groups of organic silicon thin film 10 are removed** to a desired depth, transforming into a silicon oxide film." (Emphasis added; page 5 of translation, lines 5-9.)

Similarly, Applicant admits that **Brinker** states,

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"Optionally, chemical treatment such as ozonolysis, oxygen plasma, photolysis, and selective dissolution can be used to remove residual organic constituents in order to confer additional porosity on the film." (Emphasis added; column 5, lines 25-28.)

To further clarify, for Applicant's lack of understanding of Brinker, because the only portion of the organosilicon compound is the non-oxygen and non-silicon portion, only the remaining function is that which is necessarily removed by the oxygen plasma which Brinker indicates is the "organic constituents." This specifically and necessarily means the R or R' ligands which Brinker indicates may be "alkyl" of which "methyl" or " $-\text{CH}_3$ " is the simplest. (For verification, see Hackh's Chemical Dictionary, page 27.) Ergo, the methyl groups are specifically and **necessarily** removed by the oxygen plasma.

Therefore, the express teaching of each of Wang, Morita, and Brinker, is that O_2 plasma **necessarily** removes at least some of the organic portion (i.e. methyl groups), as previously indicated by Examiner. Consequently, it is **not possible** for "the dielectric layer subjected to the exposing comprises $(\text{CH}_3)_x\text{SiO}_y$ which remains as $(\text{CH}_3)_x\text{SiO}_y$ after the exposing" as presently claimed in each of claims 16 and 18. Therefore, the rejection is maintained.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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6. Claims 1, 2, 4-7, 10-12, 14, 16, 20-25 are rejected under 35 U.S.C. 103(a) as unpatentable over **Morita** (JP 63-157443 A) in view of **Matsuura** (US 6,124,641).

Morita discloses forming a low-dielectric-constant material comprising phenyl or alkyl silicon oxide 10 which inherently has a dielectric constant of less than 3.5 over an integrated circuit Fig. 2; blanket exposing the dielectric to oxygen plasma to form an upper surface 11 of silicon oxide which is inherently effective to reduce the dielectric constant. (See Figs. 1-2; page 2, lower two column). Note that a whole of the dielectric layer is not converted from one base to another (Applicant's claim 19) and that the $(\text{CH}_3)_x\text{SiO}_y$ remains as $(\text{CH}_3)_x\text{SiO}_y$. Note that the plasma exposure time is 10 minutes. Regarding claim 14, **Morita** forms the organic silicon oxide layer using $\text{R}_n\text{Si}(\text{OH})_{4-n}$ wherein R is any alkyl group. Examiner repeats the unchallenged official notice that alkyl includes methyl as this is the simplest of the alkyl group members. (See Hackh's, *supra*).

Examiner apologizes for not having a translation available at the time of the previous office action but, instead, only having spoken with an official PTO translator, obtained the above limitations present in **Morita**. To quote from **Morita** at page 5,

"When this semiconductor substrate 1 is exposed to an **oxygen plasma** for ten minutes, the **organic functional groups** of **organic** silicon thin film 10 **are removed** to a desired depth, transforming into a silicon oxide film. As such, the film thickness of organic silicon thin film 10 as initially formed, in its thinnest portions, transforms **nearly** entirely to silicon oxide film 11; only in the thickest portion does it come so as to have a **two-layer structure of silicon oxide film 11 and organic film 10** (figure 3)." (Emphasis added; page 5 of translation, lines 5-14).

Morita does not teach chemical vapor depositing the dielectric.

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Matsuura teaches the benefits of using plasma-enhanced CVD plus an oxygen-containing compound (H_2O_2) *instead of liquid-phase deposition* of forming the dielectric layer of **Morita** consisting essentially of $(CH_3)_xSiO_y$ (methyl silicon oxide) over at least partially formed integrated circuits. (See **Matsuura**, Fig. 2; column 2, lines 14-30; columns 4-7).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify any of **Morita** to use PECVD to deposit the methyl silicon oxide, for the benefits indicated in **Matsuura**.

It is held absent evidence to the contrary that the dielectric constant is reduced by at least 10% by exposure to the oxygen plasma and that the dielectric constant is inherently stabilized. If it is thought for some reason that the dielectric constant is not reduced or is not stabilized by exposure to the oxygen plasma, then these may be a difference. But, it has been held, where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on. See In re Swinhart, 169 USPQ 226,229 (CCPA 1971). See also In re Fitzgerald, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Given the similarity (if not equality) of the dielectric materials

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formed, the present evidence indicates that the dielectric constant must necessarily be reduced and stabilized.

Regarding claims 5-7, Matsuura does not indicate that the oxygen in the oxygen plasma may come from any of O_3 , N_2O , and NO_x . Examiner repeats the unchallenged official notice that O_3 , N_2O , and NO_x are notoriously well known sources of oxygen in plasmas resulting from the plasma-induced decomposition into, among other products, highly reactive oxygen radicals. It would have been obvious to one of ordinary skill in the art at the time the invention was made to use O_3 , N_2O , or NO_x as the source of oxygen in the plasma as a matter of design choice of art recognized equivalents of plasma oxygen sources, or of routine optimization, in order to gain the best oxygen radical source of known oxygen sources for the purpose at hand.

Regarding claim 10, although the upper temperature limit for plasma exposure is not indicated in **Morita**, the choice of temperature is matter of routine optimization with a limited number of species and obvious to one of ordinary skill. See In re Aller, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). It would have been obvious to one of ordinary skill in the art at the time the invention was made to stay below an exposure temperature of 550 C to prevent degradation to the organic portion of methyl silicon oxide which portion is clearly desired to be retained in **Morita** to retain the desired properties associated with the methyl silicon oxide. It would have been obvious to one of ordinary skill in the art at the time the invention was made to optimize the exposure time as per the precedent above to optimize the resulting dielectric properties.

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Regarding claim 25, it is held absent evidence to the contrary that the dielectric layer of either of **Morita** and **Matsuura** has at least 10 to 50 mol% of methyl groups before and after exposure, based on the molecular formulas indicated therein from which the organic silicon oxide layer is formed or its final form and because only the surface portion is modified by the exposure to oxygen plasma. Furthermore, Applicant has not indicated any criticality to the claimed portions. See In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969) (Claimed elastomeric polyurethanes which fell within the broad scope of the references were held to be unpatentable thereover because, among other reasons, there was *no evidence of the criticality* of the claimed ranges of molecular weight or molar proportions.). Any difference is a matter of routine optimization within prior art general conditions which is obvious as per the precedent indicated above including In re Aller.

7. Claims 1, 2, 4-7, 10-12, 14, 16, 20-25 are rejected under 35 U.S.C. 103(a) as obvious over **Brinker** et al. (US 5,948,482) in view of **Matsuura** (US 6,124,641).

Brinker discloses forming a low-dielectric-constant material comprising, *inter alia*, methyl silicon oxide which inherently has a dielectric constant of less than 3.5 over an integrated circuit (column 1, lines 17-28; column 4, lines 8-15); blanket exposing the dielectric to oxygen plasma (column 5, lines 11-33) which is inherently effective to reduce the dielectric constant. Note that oxygen plasma exposure is used to “confer additional porosity” which inherently reduces the dielectric constant by at least 10% by incorporating more air or vacuum into the

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silicon oxide matrix (column 5, lines 25-29). Note that a whole of the dielectric layer is not converted from one base to another and that the $(\text{CH}_3)_x\text{SiO}_y$ remains as $(\text{CH}_3)_x\text{SiO}_y$. (See column 5, lines 29-33). (See also column 3, lines 29-30; column 8, Table 1).

Brinker does not teach chemical vapor depositing the dielectric.

Matsuura teaches the benefits over liquid-phase deposition of forming the dielectric layer of **Brinker** consisting essentially of $(\text{CH}_3)_x\text{SiO}_y$ (methyl silicon oxide) over at least partially formed integrated circuits, using plasma-enhanced CVD plus and an oxygen-containing compound (H_2O_2). (See **Matsuura**, Fig. 2; column 2, lines 14-30; columns 4-7).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify any of **Brinker** to use PECVD to deposit the methyl silicon oxide, for the benefits indicated in **Matsuura**.

The same reasoning regarding inherency used above is applied here.

The same reasoning applied to claims 5-7 and 10, as used above, is applied here.

Regarding claims 20-24, although the exposure time and temperature is not indicated in **Brinker**, the choice of temperature and exposure time are a matter of routine optimization with a limited number of species and obvious to one of ordinary skill. See In re Aller, 105 USPQ 233 (CCPA 1955) (selection of optimum ranges within prior art general conditions is obvious). It would have been obvious to one of ordinary skill in the art at the time the invention was made to optimize the exposure time and temperature as per the precedent above to optimize the process in **Brinker**.

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Regarding claim 25, although **Brinker** does not indicate the beginning and ending concentration of methyl groups in the range of 10% to 50%, **Brinker** indicates that only some of the organic groups are removed and that the amount removed is according to the desired properties such as porosity (i.e. dielectric constant) and hydrophobicity desired in the interlayer dielectric. It would have been obvious to one of ordinary skill in the art at the time the invention was made to choose 10 to 50 mol% of carbon as a matter of routine optimization in order to optimize the properties as indicated by **Brinker** and according to established precedent, *supra*.

8. Claims 8, 9, 65, and 34-37, 39-42, 44-46, 48-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over either of **Morita** and **Brinker**, either in view of **Matsuura** as applied to claims 1, 2, 4-7, 10-12, 14, 16, 20-25 above, and in further view of **Miyasaka** (US 6,017,779).

The prior art as explained above discloses all of the limitations of the claimed invention except for (1) that deposition and exposing in the same chamber is not taught (Applicant's claims 8 and 34); and (2) that shutting off the silicon process gas and maintaining conditions in the chamber to expose the dielectric to the oxygen plasma is not taught (Applicant's claim 35).

Miyasaka teaches a method of forming a silicon oxide layer on a semiconductor device using plasma-enhanced CVD with silicon-containing compound and a oxygen-containing gas and then shutting off the silicon-containing precursor and then exposing to the oxygen plasma in the same chamber maintained at sub-atmospheric pressure. (See **Miyasaka**, column 44, "Example 6" especially lines 35-52.)

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It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify either of **Brinker** or **Morita**, either in view of **Matsuura** to maintain a device in a single chamber as taught by **Miyasaka** in order to beneficially prevent contamination to the semiconductor device dielectric layer between process steps, as is well known in the art to do.

Response to Arguments

9. Applicant's arguments filed 5/25/01 have been fully considered but they are not persuasive.

Applicant's arguments Regarding **Morita** are clearly without merit, at least based on the translation wherein each of the features, alleged absent by Applicant, is clearly present.

The rejections over **Wang** were withdrawn because Wang does not blanket expose the organosilicon layer with plasma.

Regarding **Brinker**, Applicant appear to allege that **Brinker** is not applicable because, "Brinker et al. is not directed to a chemical vapor deposition process, and accordingly, could not suggest conducting Applicant's recited 'exposing' in any chemical vapor deposition chamber, let alone the same one within which the chemical vapor deposition occurs on a subject substrate." Examiner respectfully disagrees. In light of the applied references, which are **Brinker** in view of **Matsuura** or **Brinker** in view of **Matsuura** and in further view of **Miyasaka**-- not over **Brinker** alone. There is a clear suggestion in **Matsuura** that PECVD is better than liquid phase deposition. Furthermore, Applicant has provided no evidence whatsoever that the method of **Brinker** could not be carried out in a CVD chamber. The method of depositing and treating in the same PECVD

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chamber is clearly advantageously applied in Miyasaka which suggests to one of skill to apply its benefits to Brinker in view of Matsuura.


Conclusion

Any inquiry concerning this communication from examiner should be directed to Erik Kielin whose telephone number is (703) 306-5980 and e-mail address is erik.kielin@uspto.gov. The examiner can normally be reached by telephone on Monday through Thursday 9:00 AM until 7:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Charles Bowers, can be reached at (703) 308-2417 or by e-mail at charles.bowers@uspto.gov. The fax phone number for the group is (703) 308-7722 or -7724.

EK

June 25, 2001


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